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FORM PTO-1390 (REV 10-96) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
70563-2 /8245

U S APPLICATION NO (If known, see 37 CFR 1 5)
08/973306

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/SE97/00890	27 May 1997	29 May 1996

TITLE OF INVENTION
A ROTATING ASYNCHRONOUS CONVERTER AND A GENERATOR DEVICE

APPLICANT(S) FOR DO/EO/US
LEIJON, Mats; SCHÜTTE, Thorsten; SASSE, Christian; and FROMM, Udo

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S C 371
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U S C 371.
3. [ ] This express request to begin national examination procedures (35 U S C 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S C 371(b) and PCT Articles 22 and 39(1)
4. [ ] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information:

    Request
    International application as filed

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
	PCT/SE97/00890	70563-2 /8245

17. [x] The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
Search Report has been prepared by the EPO or JPO $930.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) $720.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $790.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1070.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $98.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 1,070	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e))	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	52 - 20 =	30	X $22.00	$ 660	
Independent claims	3 - 3 =	0	X $82.00	$ -	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1,730	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL =				$ 1,730	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)) +				$	
TOTAL NATIONAL FEE =				$ 1,730	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 1,730	
				Amount to be: refunded	$
				charged	$

a. [X] A check in the amount of $ 1,730.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ______________ in the amount of $______________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 23-0576. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO

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SIGNATURE

John P. DeLuca
NAME

25,505
REGISTRATION NUMBER

NOV 28 1997

70563-2/8245

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	PATENT
Mats LEIJON, et al.	)	Group: Unknown
Serial No: To be assigned	)	Examiner: Unknown
New appln. based on PCT/SE97/00890	)	
Filed: On Even Date	)	**ATTN: BOX PCT**
A ROTATING ASYNCHRONOUS CONVERTER AND A GENERATOR DEVICE	)	

* * * * * *

PRELIMINARY AMENDMENT

Washington, D.C.
NOV 28 1997

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Concurrently with the U.S. national filing of this application, please amend the present application as follows:

IN THE CLAIMS:

Amend claims 1-41 as follows:

Claim 1. (Amended) A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator

connected to a second AC network with a second frequency f_2, [characterized in that] wherein the converter [also] comprises [a] rotor means which rotates in dependence of the first and second frequencies f_1, f_2, and [in that at least] wherein at least one of said stators [each] comprises at least one winding, including [wherein each winding comprises] at least one current-carrying conductor, and [each winding comprises] an insulation system including [, which comprises on the one hand] at least two semiconducting layers, wherein each layer forms a [constitutes] substantially [an] equipotential surface, and [on the other hand between them is arranged] a solid insulation located between the first and second layers.

Claim 2 (Amended), line 2, delete “characterized in that” and insert --wherein--.

Claim 3 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 4. (Amended) The rotating asynchronous converter according to [Claim 2 or 3, characterized in that] claim 1, wherein an outer one of said layers is arranged to constitute substantially an equipotential surface surrounding said conductor.

Claim 5 (Amended), line 2, delete “characterized in that” and insert --wherein--.

Claim 6 (Amended), line 2, delete “characterized in that” and insert --wherein--.

Claim 7. (Amended) The rotating asynchronous converter according to [any one of the Claims 1, 2, 3, 4, 5, or 6, characterized in that] claim 1, wherein at least two of said layers have substantially equal thermal expansion coefficients.

Claim 8. (Amended) The rotating asynchronous converter according to [any one of the preceding claims, characterized in that] claim 1, wherein said current-carrying conductor comprises a number of strands, only a minority of said strands being non-isolated from each other.

Claim 9. (Amended) The rotating asynchronous converter according to [any one of the preceding Claims, characterized in that] claim 1, wherein each of said two layers and said solid insulation is [fixed] fixedly connected to adjacent layer or solid insulation along substantially the whole connecting surface.

Claim 10. (Amended) A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2, [characterized in that] wherein the converter [also comprises a] further comprises rotor means which rotates in dependence of said first and second frequencies f_1, f_2[and[in that]said stators each comprise[s] at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor.

Claim 11 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 12 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 13. (Amended)The rotating asynchronous converter according to [any one of Claims 1-12, characterized in that] claim 1, wherein said rotor means comprises two electrically and mechanically connected rotors, which are concentrically arranged in respect of said stators.

Claim 14 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 15 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 16. (Amended) The rotating asynchronous converter according to [any one of Claims 1-11, characterized in that] calim 1 wherein said rotor means comprises a single [only one] rotor concentrically arranged in respect of said stators.

Claim 17 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 18 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 19 (Amended, line 6, delete "characterized in that" and insert --wherein--.

Claim 20 (Amended, line 5, delete "characterized in that" and insert --wherein--.

Claim 21 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 22 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 23. (Amended) The generator device according to [Claim 21 or 22, characterized in that] <u>claim 21, wherein</u> an outer one of said layers is arranged to constitute substantially an equipotential surface surrounding said conductor.

Claim 24 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 25 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 26 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 27. (Amended) The generator device according to [any one of Claims 20-26, characterized in that] <u>claim 20, wherein</u> said current-carrying conductor comprises a number of strands, only a minority of said strands being non-isolated from each other.

Claim 28. (Amended) The generator device according to {any one of claims 20-27, characterized in that] <u>claim 20, wherein</u> each of said two layers and said solid insulation is fixed connected to adjacent layer or solid insulation along substantially the whole connecting surface.

Claim 29 (Amended), line 5, delete "characterized in that" and insert --wherein--.

Claim 30 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 31 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 32. (Amended) The generator device according to [any one of Claims 20-31, characterized in that] claim 29, wherein said rotor means comprises two electrically and mechanically connected rotors, wherein said rotors are hollow and arranged concentrically around said stator and said cylindrical rotor.

Claim 33 (Amended, line 2, delete "characterized in that" and insert --wherein--.

Claim 34 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 35. (Amended) The generator device according to [any one of Claims 20-31, characterized in that] claim 29, wherein said rotor means comprises a first rotor and a second rotor, which rotors are electrically and mechanically connected, wherein said first rotor is hollow and arranged concentrically around said first cylindrical rotor, and said second rotor is cylindrical.

Claim 36 (Amended), line 2, delete "characterized in that" and insert --wherein--.

Claim 37 (Amended, line 2, delete "characterized in that" and insert --wherein--.

Claim 38. (Amended) The use of a rotating asynchronous converter in accordance with [any one of Claims 1-19] claim 1 for connection of [not] non-synchronous three phase networks with equal rating frequencies.

Claim 39. (Amended) The use of a rotating asynchronous converter in accordance with [any one of Claims 1-19] claim 1 for connection of three phase networks with different frequencies.

Claim 40. (Amended) The use of a rotating asynchronous converter in accordance with [any one of Claims 1-19] claim 1 as a series compensation in long distance AC transmission.

Claim 41. (Amended) The use of a rotating asynchronous converter in accordance with [any one of Claims 1-19] claim 1 for reactive power compensation.

Add new claims 42-54 as follows:

--42. A rotating asynchronous converter employing a high voltage electric machine comprising a stator, a rotor and a winding, wherein at least one of said windings comprises a cable including at least one current-carrying conductor and a magnetically permeable, electric field confining cover surrounding the conductor, said cable forming at least one uninterrupted turn in the corresponding winding of said machine.

43. The converter of claim 42, wherein the cover comprises an insulating layer surrounding the conductor and an outer layer surrounding the insulating layer, said outer layer having a conductivity sufficient to establish an equipotential surface around the conductor.

44. The converter of claim 42, wherein the cover comprises an inner layer surrounding the conductor and being in electrical contact therewith; an insulating layer surrounding the inner layer and an outer layer surrounding the insulating layer.

45. The converter of claim 44, wherein the inner and outer layers have semiconducting properties.

46. The converter of claim 42, wherein the cover is formed of a plurality of layers including an insulating layer and wherein said plurality of layers are substantially void free.

47. The converter of claim 42, wherein the cover is in electrical contact with the conductor.

48. The converter of claim 47, wherein the layers of the cover have substantially the same temperature coefficient of expansion.

49. The converter of claim 42, wherein the machine is operable at 100% overload for two hours.

50. The converter of claim 42, wherein the cable is operable free of sensible end winding loss.

51. The converter of claim 42, wherein the winding is operable free of partial discharge and field control.

52. The converter of claim 42, wherein the winding comprises multiple uninterrupted turns.

53. The converter of claim 42, wherein the cable comprises a transmission line.

54. The converter of claim 42, wherein the cable is flexible.--

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If any multiple dependencies exist in the claims, it is respectfully requested that such dependencies be removed.

REMARKS

By this Preliminary Amendment claims have been amended to better conform the claims with U.S. practice and to remove multiple dependencies therefrom. New claims set forth the invention in a different scope.

REMARKS

By this Preliminary Amendment claims 1-41 have been amended to better conform with U.S. practice. Entry is in order.

Respectfully submitted,

John P. DeLuca
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JPD:jlh

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A ROTATING ASYNCHRONOUS CONVERTER AND A GENERATOR DEVICE

Technical field of the invention

The present invention relates to a rotating asynchronous converter in accordance with the introductory part of Claims 1, 10, and 19, and the use of such converter.

The present invention also relates to a generator device in accordance with the introductory part of Claims 20 and 29.

Background of the invention

In a number of situations exchange of power must be performed between AC networks with different or at least not synchronous frequencies. The most frequent cases are the following:

1. Connection of not synchronous three phase networks with equal rating frequencies, e.g. between eastern and western Europe.
2. Connection of three phase networks with different frequencies, most usually 50 Hz/60 Hz (e.g. Japan, Latin America).
3. Connection of a three phase network and a low frequency, one/two phase network for railway supply, in Europe 50 Hz/16.2/3 Hz, in USA 60 Hz/25 Hz.
4. The use of rotating asynchronous converters as a series compensation in long distance AC transmission.

Today, the connection is performed with the aid of power electronics and DC intermediate link. In the above mentioned cases 2 and 3 the connection can further be performed with the aid of matrix converters. In case of synchronous, but different frequencies in the above mentioned cases 2 and 3 the connection can further be performed with the aid of rotating converters comprising mechanically connected synchronous machines.

In the article, "Investigation and use of asynchronized machines in power systems", Electric Technology USSR, No. 4, pp. 90-99, 1985, by N.I. Blotskii, there is disclosed an asynchronized machine used for interconnection of power systems, or their parts, which

have different rated frequencies, or the same rated frequencies, but differing in the degree of accuracy with which it must be maintained. The structure of the asynchronized machine is disclosed in figure 1. The asynchronized machine includes an electric machine 1 which is a machine with a conventional three-phase stator and either a non-salient-pole symmetrical rotor or a salient-pole or non-salient-pole electrically asymmetrical rotor, the phase leads being connected to slip rings; an exciter 2 which is a cycloconverter or reversing controlled rectifier, the cycloconverter supply 3 or 4, a regulator 5 forming the control law required for the rotor ring voltages and the main machine rotor angle and speed 6, voltage 7 and current 9 sensors of the stator and rotor.

In the article, "Performance Characteristics of a Wide Range Induction type Frequency Converter", IEEMA Journal, Vol. 125, No. 9, pp. 21-34, September 1995, by G.A. Ghoneem, there is disclosed an induction-type frequency converter as a variable frequency source for speed control drives of induction motors. In figure 2 there is disclosed a schematic diagram of the induction-type frequency converter. The induction-type frequency converter consists of two mechanically and electrically coupled wound rotor induction machines A, B. The stator windings of one of them (A) are connected to 3-phase supply at line frequency (Vi, Fi), while the stator windings of the other machine (B) represent the variable frequency output (Vo, Fo). The rotor windings 10, 12 of the two machines are connected together with special arrangement. The converter is driven by a variable speed primemover 14, a DC motor can be used.

Static converters have drawbacks such as relatively low efficiency (ca 95%) owing to the losses in the semi-conductors, harmonics which have to be compensated with the aid of filters. The use of DC intermediate links leads to the use of special converter transformers with very complex design. The fillers are leading to a great need of space for the total assembly. Conventional rotating

converters are not designed for high voltages, so a transformer is needed at each side for the connection to the AC network. The efficiency then becomes comparable to or even lower than the efficiency of a static converter.

Summary of the invention

The object of the invention is to solve the above mentioned problems and to provide a rotating asynchronous converter for connection of AC networks with equal or different frequencies. This object is achieved by providing a rotating asynchronous converter defined in the introductory part of Claim 1, 10, or 19 with the advantageous features of the characterizing part of said Claims.

Accordingly, the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2. The converter also comprises a rotor means which rotates in dependence of the first and second frequencies f_1, f_2. At least one of the stators each comprise at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

According to another embodiment of the converter, it comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2. The converter also comprises a rotor means which rotates in dependence of said fist and second frequencies f_1, f_2. The stators each comprise at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor, each conductor comprises a number of strands, around said conductor is arranged an inner semiconducting layer, around said inner semiconducting layer is arranged an insulating layer of solid insulation,

and around said insulating layer is arranged an outer semi-conductor layer.

According to another embodiment of the converter, it comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2. The converter also comprises a rotor means which rotates in dependence of said first and second frequencies f_1, f_2. The stators each comprises at least one winding, wherein each winding comprises at least one currect-carrying conductor. Each winding also comprises an insulation system, which in respect of its thermal and electrical properties permits a voltage level in said rotating asynchronous converter exceeding 36 kV.

A very important advantage of the present invention as defined in Claim 1, 10, or 19, is that it is possible to achieve a connection of two not synchronous networks without the further use of transformers or any other equipment. Another advantage is the high efficiency, which is expected to be 99%.

By designing the insulation system, which suitably is solid, so that it in thermal and electrical view is dimensioned for voltages exceeding 36 kV, the system can be connected to high voltage power networks without the use of intermediate step-down-transformers, whereby is achieved the above referenced advantages. Such a system is preferably, but not necessarily, designed in such a way that it comprises the features of the rotating asyn-chronous converter according to any one of Claims 1-19.

Another object of the invention is to solve the above mentioned problems and to provide a generator device with variable rotational speed. This object is achieved by providing a generator device deined in the introductory part of Claim 20 or 29 with the advantageous features of the characterising parts of said Claims.

Accordingly, the generator device comprises a stator connected to an AC network with a frequency f_2, a first cylindrical rotor connected to a turbine, which rotates

with a frequency f_1. The generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2. The stator and the first cylindrical rotor each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

According to another embodiment of the generator device, it comprises a stator connected to an AC network with a frequency f_2, and a first cylindrical rotor connected to a turbine, which rotates with a frequency f_1. The generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2. The stator and the first cylindrical rotor each comprises at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor, each conductor comprises a number of strands, around said conductor is arranged an inner semiconducting layer, around said inner semiconducting layer is arranged an insulating layer of solid insulation, and around said insulating layer is arranged an outer semiconducting layer.

The above mentioned and other preferable embodiments of the present invention are specified in the dependent Claims.

In a certain aspect of the present invention it relates to the use of the invented asynchronous converter in specific applications such as those specified in Claims 38-41, in which applications the advantages of the invented device are particularly prominent.

Embodiments of the invention will now be described with a reference to the accompanying drawings, in which:

Brief description of the Drawings

Figure 1 shows a schematic diagram of an asynchronized machine used for interconnection of power system according to the state of the art;

Figure 2 shows a schematic diagram of an induction-type frequency converter as a variable frequency source according to the state of the art;

Figure 3 shows the parts included in the current modified standard cable;

Figure 4 shows a first embodiment of a rotating asynchronous converter according to the present invention;

Figure 5 shows a second embodiment of the rotating asynchronous converter according to the present invention;

Figure 6 shows a first embodiment of a generator device according to the present invention ; and

Figure 7 shows a second embodiment of the generator device according to the present invention.

Detailed description of Embodiments

A preferred embodiment of the improved cable is shown in Figure 3. The cable 20 is described in the figure as comprising a current-carrying conductor 22 which comprises transposed both non-insulated and insulated strands. Electromechanically transposed, extruded there is an inner semiconducting casing 24 which, in turn, is surrounded by an extruded insulation layer 26. This layer is surrounded by an external semiconducting layer 28. The cable used as a winding in the preferred embodiment has no metal shield and no external sheath.

Preferably, at least two of these layers, and most preferably all of them, has equal thermal expansion coefficients. Hereby is achieved the crucial advantage that in case of thermal motion in the winding, one avoids defects, cracks or the like.

Figure 4 shows a first embodiment of a rotating asynchronous converter 30 according to the present invention. The rotating asynchronous converter 30 is used

for connection of AC networks with equal or different frequencies. The converter 30 comprises a first stator 32 connected to a first AC network (not disclosed) with a first frequency f_1, and a second stator 34 connected to a second AC network (not disclosed) with a second frequency f_2. In the disclosed embodiment the stators 32, 34 are three phase stators 32, 34 comprising three windings each, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation. The windings can also be formed of a cable of the type disclosed in figure 3. The converter 30 also comprises a rotor means 36 which rotates in dependence of the first and second frequencies f_1, f_2. In the disclosed embodiment the rotor means 36 comprises two electrically and mechanically connected three phase rotors 36_1, 36_2, which are concentrically arranged in respect of said stators 32, 34. The converter 30 also comprises an auxiliary device 38 connected to said rotors 36_1, 36_2 for starting up of the rotors 36_1, 36_2 to a suitable rotation speed before connection of said converter 30 to said AC networks. Each rotor 36_1, 36_2 comprises a low voltage winding (not disclosed). When the first stator 32 is connected to a three phase AC network with the frequency f_1 and the second stator 34 is connected to a three phase AC network with the frequency f_2, the rotors 36_1, 36_2 will rotate with the frequency $(f_1-f_2)/2$ and the stator current has the frequency $(f_1+f_2)/2$. The efficiency with such a converter will be very high (~99%) for small frequency differences due to the fact that all power is transmitted as in a transformer. Assuming $f_1<f_2$, a proportion $\frac{f_1-f_2}{f_2}$ of the power is transmitted mechanically and the remainder $\frac{f_1}{f_2}$

of the power is transmitted by transformer action. Mechanical power is only consumed to maintain the rotation.

In figure 5 there is disclosed a second embodiment of the rotating asynchronous converter 40 according to the present invention. The rotating asynchronous converter 40 is also used for connection of AC networks with equal or different frequencies. The converter 40 comprises a first stator 42 connected to a first AC network (not disclosed) with a first frequency f_1, and a second stator 44 connected to a second AC network (not disclosed) with a second frequency f_2. In the disclosed embodiment the stators 42, 44 are three phase stators 42, 44 comprising three windings each, wherein each winding can be of the type described in connection to figure 4. The converter 40 also comprises a rotor means 46 which rotates in dependence of the first and second frequencies f_1, f_2. In the disclosed embodiment the rotor means 46 comprises only one rotor 46 concentrically arranged in respect of said stators 42, 44. Said rotor 46 also comprises a first loop of wire 48 and a second loop of wire 50, wherein said loops of wire 48, 50 are connected to each other and are arranged opposite each other on said rotor 46. The loops of wire 48, 50 are also separated by two sectors 52_1, 52_2, wherein each sector 52_1, 52_2 has an angular width of α. The converter 40 also comprises an auxiliary device (not disclosed) connected to said rotor 46 for starting up of the rotor 46 to a suitable rotational speed before connection of said converter 40 to said AC networks. To compensate for the frequency difference Δf, the rotor 46 only needs to rotate with the frequency $f_R = \frac{\pi-\alpha}{\pi} \cdot \frac{\Delta f}{4}$,

wherein $\Delta f = |f_1-f_2|$. For $\alpha=\pi/4$ this means $f_R = \frac{3\Delta f}{16}$, i.e. a very low rotational frequency. The main advantages with this embodiment are the low rotational frequency and the use of only one rotor.

In figure 6 there is disclosed a first embodiment of a generator device 60 with variable rotational speed according to the present invention. The generator device 60 comprises a stator 62 connected to an AC network (not disclosed) with a frequency f_2 and a first cylindrical rotor 64 connected to a turbine 66, which rotates with a frequency f_1. The generator device 60 comprises also a rotor means 68 which rotates in dependence of the frequencies f_1, f_2. The stator 62 and said first cylindrical rotor 64 each comprises at least one winding (not disclosed). Each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation. Each winding can in another embodiment also comprise a cable of the type disclosed in figure 3. The rotor means 68 comprises two electrically and mechanically connected rotors 68_1, 68_2, which rotors 68_1, 68_2 are hollow and arranged concentrically around said stator 62 and said cylindrical rotor 64. The stator 62 in the disclosed embodiment has a cylindrical shape. The rotors 68_1, 68_2 each comprises a low voltage winding (not disclosed) and they are rotating with the frequency $(f_1-f_2)/2$ when said generator device is in operation. The frequency of the rotor current will be $(f_1+f_2)/2$ when the generator device 60 is in operation. This generator device 60 is now disconnected from the power frequency and can be operated with the frequency as an optimizeable parameter. This generator device 60 will also give a better efficiency and power matching than a conventional generator.

In figure 7 there is disclosed a second embodiment of the generator device 70 according to the present invention. The generator device 70 comprises a stator 72 connected to an AC network (not disclosed) with a frequency f_2 and a first cylindrical rotor 74 connected to a turbine 76, which rotates with a frequency f_1. The

generator device 70 also comprises a rotor means 78 which rotates in dependence of the frequencies f_1, f_2. The stator 72 and said first cylindrical rotor 74 each comprises at least one winding (not disclosed). The winding can be of the types which were mentioned in the description in connection to figure 6. The rotor means 78 comprises a first rotor 78_1 and a second rotor 78_2, which rotors 78_1, 78_2 are electrically and mechanically connected to each other. The first rotor 78_1 is hollow and arranged concentrically around said first cylindrical rotor 74 and said second rotor 78_2 is cylindrical and surrounded by the stator 72. The first and second rotors 78_1, 78_2 of said rotor means 78 each comprises a low voltage winding and said rotors 78_1, 78_2 are rotating with the frequency $(f_1-f_2)/2$ when said generator device 70 is in operation. The stator 72 is hollow and arranged around said second rotor 78_2. This generator device 70 works in the same way and has the same advantages as the generator device 60 disclosed in figure 6.

The disclosed embodiments only show connection of three phase networks, but the invention is also applicable for connection of a three phase network, wherein one stator has a one/two phase application. The invention can also be used for connection of a three phase network and a one/two phase network, wherein one stator having a three phase application is connected via a Scott-connection or another symmetrical connection to a one/two phase network. The invention is also applicable to more than two stators and rotor parts to connect more than two AC networks. The only condition is that only two not synchronous networks are connected.

The invention is not limited to the embodiments described in the foregoing. It will be obvious that many different modifications are possible within the scope of the following claims.

CLAIMS

1. A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2, **characterized in** that the converter also comprises a rotor means which rotates in dependence of the first and second frequencies f_1, f_2, and in that at least one of said stators each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

2. The rotating asynchronous converter according to Claim 1, **characterized in** that at least one of said semiconducting layers has in the main equal thermal expansion coefficient as said solid insulation.

3. The rotating asynchronous converter according to Claim 2, **characterized in** that the potential of the inner one of said layers is substantially equal to the potential of the conductor.

4. The rotating asynchronous converter according to Claim 2 or 3, **characterized in** that an outer one of said layers is arranged to constitute substantially an equipotential surface surrounding said conductor.

5. The rotating asynchronous converter according to claim 4, **characterized in** that said outer layer is connected to a specific potential.

6. The rotating asynchronous converter according to Claim 5, **characterized in** that said specific potential is ground potential.

7. The rotating asynchronous converter according to any one of the Claims 1, 2, 3, 4, 5, or 6, **characterized in**

that at least two of said layers have substantially equal thermal expansion coefficients.

8. The rotating asynchronous converter according to any one of the preceding Claims, **characterized in** that said current-carrying conductor comprises a number of strands, only a minority of said strands being non-isolated from each other.

9. The rotating asynchronous converter according to any one of the preceding Claims, **characterized in** that each of said two layers and said solid insulation is fixed connected to adjacent layer or solid insulation along substantially the whole connecting surface.

10. A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2, **characterized in** that the converter also comprises a rotor means which rotates in dependence of said first and second frequencies f_1, f_2, and in that said stators each comprises at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor,

- each conductor comprises a number of strands
- around said conductor is arranged an inner semiconducting layer,
- around said inner semiconducting layer is arranged an insulating layer of solid insulation, and
- around said insulating layer is arranged an outer semiconducting layer.

11. The rotating asynchronous converter according to Claim 10, **characterized in** that said cable also comprises a metal shield and a sheath.

12. The rotating asynchronous converter according to Claim 11, **characterized in** that the cable has a diameter comprised in the approximate interval 20-250 mm and a conductor area comprised in the approximate interval 80-3000 mm^2.

13. The rotating asynchronous converter according to any one of Claims 1-12, **characterized in** that said rotor means comprises two electrically and mechanically connected rotors, which are concentrically arranged in respect of said stators.

14. The rotating asynchronous converter according to Claim 13, **characterized in** that said converter also comprises an auxiliary device connected to said rotors for starting up of the rotors to a suitable rotation speed before connection of said converter.

15. The rotating asynchronous converter according to Claim 14, **characterized in** that said rotors each comprises a low voltage winding, and in that said rotors are rotating with the frequency $(f_1-f_2)/2$ and the stator current has the frequency $(f_1+f_2)/2$ when said converter is in operation.

16. The rotating asynchronous converter according to any one of Claims 1-11, **characterized in** that said rotor means comprises only one rotor concentrically arranged in respect of said stators.

17. The rotating asynchronous converter according to Claim 16, **characterized in** that said rotor comprises a first loop of wire and a second loop of wire, wherein said loops of wire are connected to each other and are arranged opposite each other on said rotor and separated by two sectors, wherein each sector has an angular width of α.

18. The rotating asynchronous converter according to Claim 17, **characterized in** that said converter also comprises an auxiliary device connected to said rotor for starting up of the rotor to a suitable rotational speed before connection of said converter, and in that said rotor is rotating with the frequency $f_R = \frac{\pi-\alpha}{\pi} \cdot \frac{\Delta f}{4}$, wherein $\Delta f = |f_1-f_2|$.

19. A rotating asynchronous converter for connection of AC networks with equal or different frequencies, wherein the converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second

stator connected to a second AC network with a second frequency f_2, **characterized in** that the converter also comprises a rotor means which rotates in dependence of the first and second frequencies f_1, f_2, and in that said stators each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and also comprising an insulation system, which in respect of its thermal and electrical properties permits a voltage level in said rotating asynchronous converter exceeding 36 kV.

20. A generator device with variable rotational speed, wherein the generator device comprises a stator connected to an AC network with a frequency f_2, a first cylindrical rotor connected to a turbine, which rotates with a frequency f_1, **characterized in** that said generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2, and in that said stator and said first cylindrical rotor each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

21. The generator device according to Claim 20, **characterized in** that at least one of said semiconducting layers has in the main equal thermal expansion coefficient as said solid insulation.

22. The generator device according to Claim 21, **characterized in** that the potential of the inner one of said layers is substantially equal to the potential of the conductor.

23. The generator device according to Claim 21 or 22, **characterized in** that an outer one of said layers is arranged to constitute substantially an equipotential surface surrounding said conductor.

24. The generator device according to Claim 23, **characterized in** that said outer layer is connected to a specific potential.

25. The generator device according to Claim 24, **characterized in** that said specific potential is ground potential.

26. The generator device according to any one of Claims 20-25, **characterized in** that at least two of said layers have substantially equal thermal expansion coefficients.

27. The generator device according to any one of Claims 20-26, **characterized in** that said current-carrying conductor comprises a number of strands, only a minority of said strands being non-isolated from each other.

28. The generator device according to any one of claims 20-27, **characterized in** that each of said two layers and said solid insulation is fixed connected to adjacent layer or solid insulation along substantially the whole connecting surface.

29. A generator device with variable rotational speed, wherein the generator device comprises a stator connected to an AC network with a frequency f2, a first cylindrical rotor connected to a turbine, which rotates with a frequency f_1, **characterized in** that said generator device also comprises a rotor means which rotates in dependence of the frequencies f_1, f_2, and in that said stator and said first cylindrical rotor each comprises at least one winding, wherein each winding comprises a cable comprising at least one current-carrying conductor,

- each conductor comprises a number of strands,
- around said conductor is arranged an inner semiconducting layer,
- around said inner semiconducting layer is arranged an insulating layer of solid insulation, and
- around said insulating layer is arranged an outer semiconducting layer.

30. The generator device according to Claim 29, **characterized in** that said cable also comprises a metal shield and a sheath.

31. The generator device according to Claim 30, **characterized in** that the cable has a diameter comprised in the approximate interval 20-250 mm and a conductor area comprised in the approximate interval 80-3000 mm^2.

32. The generator device according to any one of Claims 20-31, **characterized in** that said rotor means comprises two electrically and mechanically connected rotors, wherein said rotors are hollow and arranged concentrically around said stator and said cylindrical rotor.

33. The generator device according to Claim 32, **characterized in** that said rotors of said rotor means each comprises a low voltage winding, and in that said rotor is rotating with the frequency $(f_1-f_2)/2$ when said generator device is in operation.

34. The generator device according to Claim 33, **characterized in** that said stator has a cylindrical shape.

35. The generator device according to any one of Claims 20-31, **characterized in** that said rotor means comprises a first rotor and a second rotor, which rotors are electrically and mechanically connected, wherein said first rotor is hollow and arranged concentrically around said first cylindrical rotor, and said second rotor is cylindrical.

36. The generator device according to Claim 35, **characterized in** that said first and second rotors of said rotor means each comprises a low voltage winding, and in that said first and second rotors are rotating with the frequency $(f_1-f_2)/2$ when said generator device is in operation.

37. The generator device according to Claim 36, **characterized in** that said stator is hollow and arranged around said second rotor.

38. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 for connection of not synchronous three phase networks with equal rating frequencies.

39. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 for connection of three phase networks with different frequencies.

40. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 as a series compensation in long distance AC transmission.

41. The use of a rotating asynchronous converter in accordance with any one of Claims 1-19 for reactive power compensation.

ABSTRACT

The present invention relates to a rotating asynchronous converter and a generator device. The converter comprises a first stator connected to a first AC network with a first frequency f_1, and a second stator connected to a second AC network with a second frequency f_2. The converter also comprises a rotor means which rotates in dependence of the first and second frequencies f_1, f_2. The stators each comprises at least one winding, wherein each winding comprises at least one current-carrying conductor, and each winding comprises an insulation system, which comprises on the one hand at least two semiconducting layers, wherein each layer constitutes substantially an equipotential surface, and on the other hand between them is arranged a solid insulation.

Fig. 1

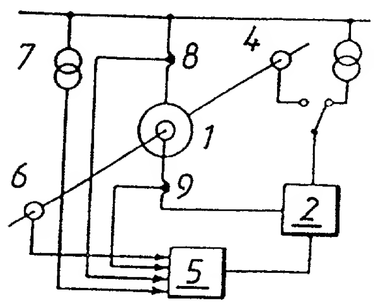


Fig. 2

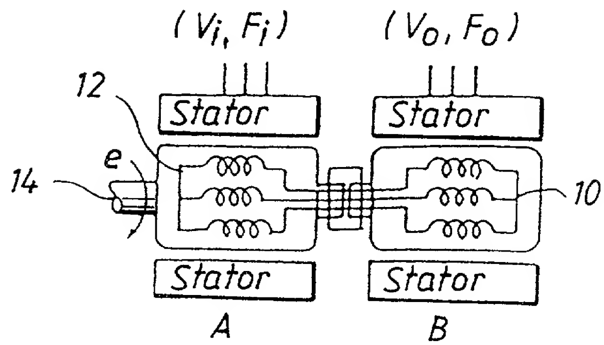


Fig. 3

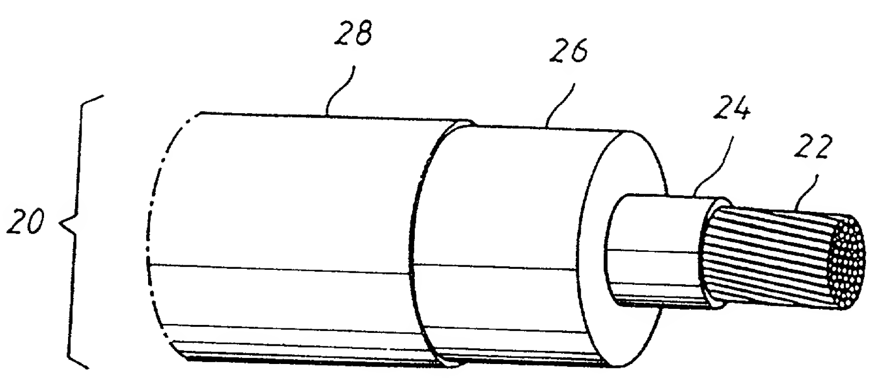
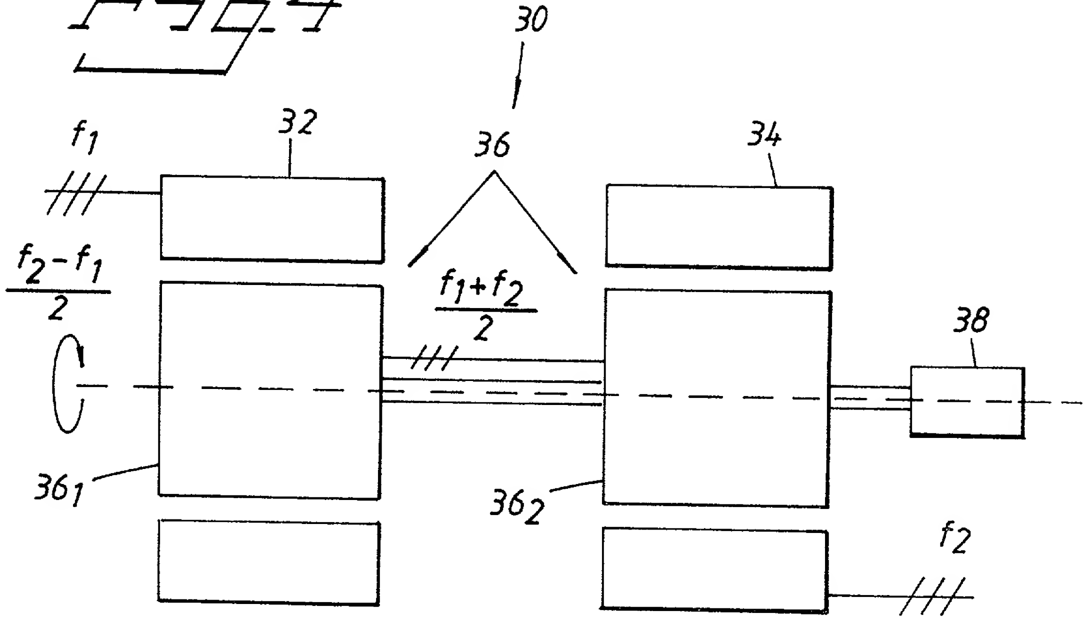


Fig. 4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32
34
36
f_1
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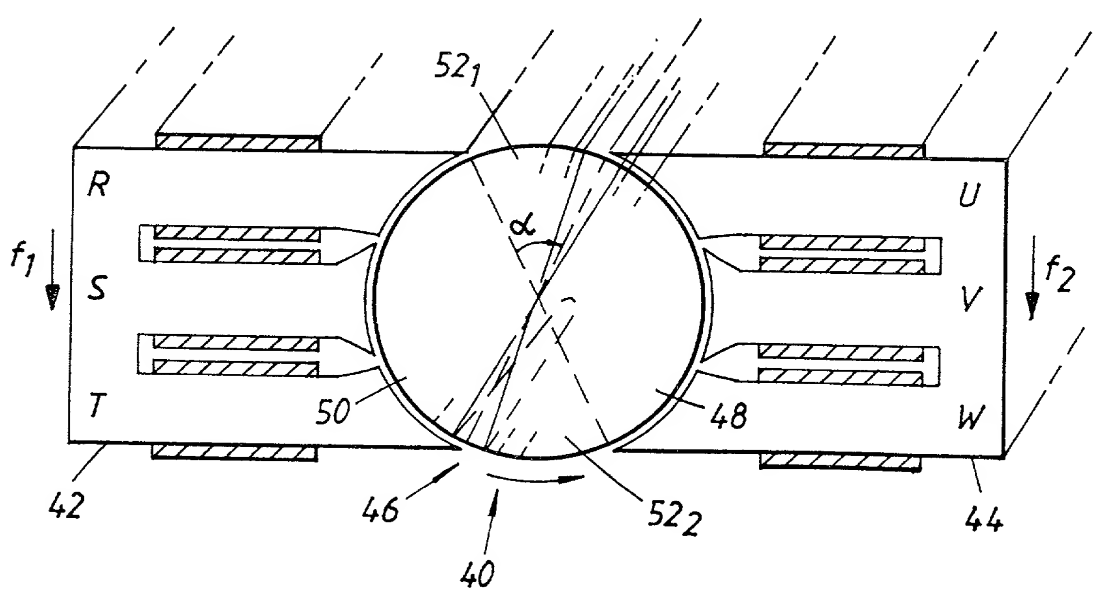
$\frac{f_1+f_2}{2}$
38
36_1
36_2
f_2

Fig. 5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f_2
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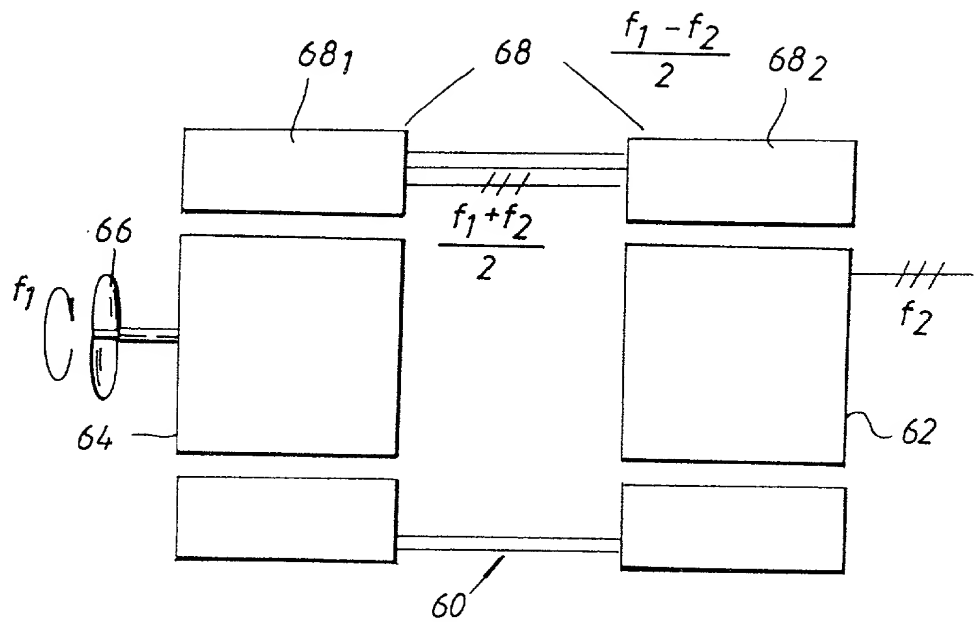
46
52_2
44
40

Fig. 6



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68_2
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f_2
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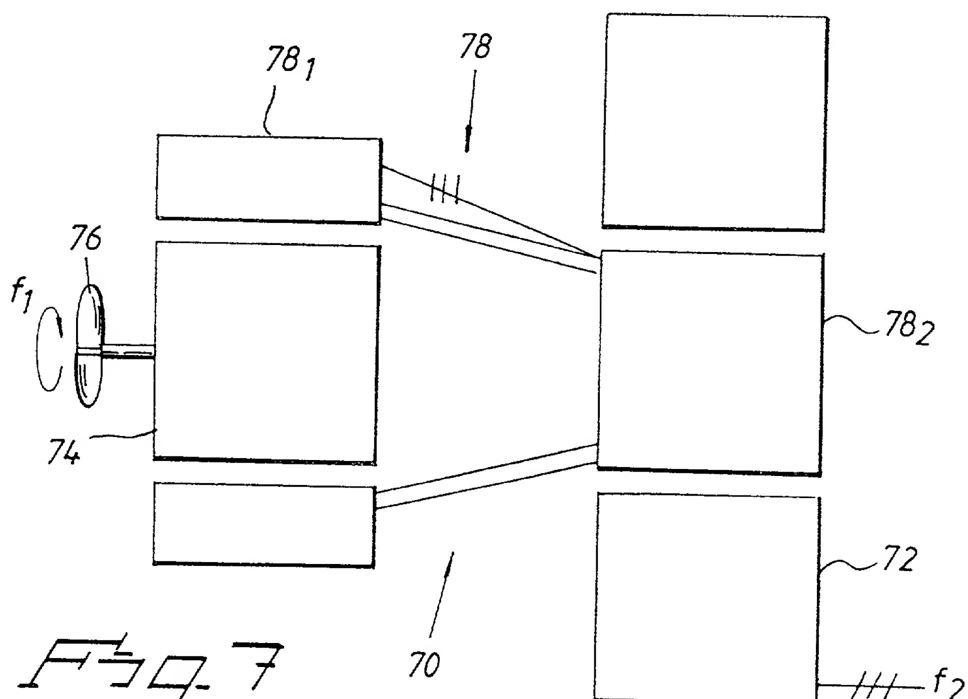

78_1
78
76
f_1
78_2
74
72
70
f_2

Fig. 7

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY PATENT APPLICATION (Includes PCT)	Attorney Docket No. 70563-2/8245

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A ROTATING ASYNCHRONOUS CONVERTER AND A GENERATOR DEVICE

the specification of which (check one)

[ ] is attached hereto.

[ ] was filed on ________________ as Application Serial No. __________.

[X] was filed as PCT international application no. PCT/SE97/00890 on 27 May 1997, and was amended under PCT Article 19 on __________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I do not know and do not believe the claimed invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application.

I hereby claim priority benefits under Title 35, United States Code §119 of any application(s) for patent or inventor's certificate listed below and have also identified below any application for patent or inventor's certificate having a filing date before that of the application(s) on which priority is claimed:

Prior Application(s)			Priority Claimed	
9602079-7	Sweden	29 May 1996	[x]	[ ]
(Number)	(Country)	Day/Month/Year Filed	Yes	No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) or PCT international application(s) designating the United States of America listed below and, insofar as the subject matter of each of the claims of this application

73 Rec'd PCT/PTO 10 APR 1998

705/70563-2/8245

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	PATENT
	)	
Mats LEIJON et al.	)	Group:
	)	
Serial No.: 08/973,306	)	Examiner:
Based on PCT/SE97/00890	)	
	)	**ATTENTION: BOX PCT**
Filed: November 28, 1997	)	
	)	
A ROTATING ASYNCHRONOUS CONVERTER AND A GENERATOR DEVICE	)	

* * * * * *

CHANGE OF FIRM NAME AND ADDRESS

Washington, D.C.
April 10, 1998

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The undersigned attorney of record requests that the change of firm name and address be entered in the above-identified application and all future correspondence be forwarded to the undersigned at:

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in the prior is not disclosed in the prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status (patented, pending, abandoned)
Application Serial No.	Filing Date	Status (patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Robert J. Lasker, Reg. No. 22,785; Lawrence R. Radanovic, Reg. No. 23,077; Richard H. Tushin, Reg. No. 27,297; Donald N. Huff, Reg. No. 27,561; and John P. DeLuca, Reg. No. 25,505. Direct all telephone calls to telephone no. (202) 628-0088 and faxes to (202) 628-8034.

Address all correspondence to John P. DeLuca, Esq., Watson Cole Grindle Watson, P.L.L.C., 1400 K Street, N.W., Suite 1000, Washington, D.C. 20005-2477.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Attorney Docket No.
70563-2/8245

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